

# Plastics in the circular economy: LCA based indicators to guide the waste management policy in Flanders

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## 1. Introduction

Recently, the European Commission has released its circular economy package to stimulate the implementation of a more resource efficient and circular economy [1]. One of the key materials for which still a lot of progress can be made in this sense is plastics [2], which importance keeps on growing to a global production of 311 million tons in 2014 [3]. Given its large masses dispersed in a huge array of applications, and their potential environmental impact when released in nature, many governments implement measures to improve the sustainability of plastic waste management. To monitor progress, suitable indicators are needed, of which many are situated at the macro-economic level and fewer at the micro-level (products, companies). For this purpose, often LCA is used as a valuable framework for environmental impact assessment, yet facing significant challenges towards policy making:

- Performing an LCA of waste valorisation schemes is complex and needs a lot of value choices (probably even more than in the assessment of traditional product systems) which makes comparisons amongst waste management scenarios difficult
- LCA is typically a multi-indicator result, which makes interpretation complex
- LCA does not take into account the technical reality; it considers waste equal, regardless of its quality

Therefore, LCA based sustainability indicators are required that are on the one hand more robust and on the other hand easier in communication. One indicator that has interesting properties towards facing these challenges is the Recyclability Benefit Rate (RBR) developed by the European Commission's Joint Research Centre. It is defined as the ratio of the environmental benefits that can be obtained from recycling a product, over the environmental burdens related to production from virgin resources followed by disposal. This indicator is being used in Flanders by the Policy Research Centre for Sustainable Material Management (Summa) to support waste management policies in Flanders. This work will now give an overview of 4 years experience in the practical implementation of the indicator, the advantages and disadvantages, adaptations that have been made to make the indicator more advanced; e.g. for including quality or for including multiple recycling loops or open loops and also on the way how it is used by the Flemish government to guide subsidies and taxes for plastic waste management [5,6].

## 2. Materials and methods

The current Recyclability Benefit Rate, in a simplified version, is defined as:

$$RBR = \frac{RCR (V_{\alpha_0} + D_{\alpha_0} - R_{\alpha_0})}{V_{\alpha_0} + D_{\alpha_0}}$$

In which the denominator describes the life cycle based environmental impact of the wasted product's ( $\alpha_0$ ) virgin production (V) and disposal (D), and the numerator describes the environmental savings obtained from recycling this product  $\alpha_0$ . This indicator is first modified to take into account open loop recycling and multiple loops (n):

$$OLRBR_{nstep} = \frac{\sum_{i=1}^n \left( RCR^i \frac{m_{v\alpha_i}}{m_{r\alpha_i}} V_{\alpha_i} \right) + (RCR^n D_{\alpha_n}) - \sum_{i=0}^{n-1} (RCR^{i+1} R_{\alpha_i \rightarrow \alpha_{i+1}})}{V_{\alpha_0} + D_{\alpha_0}}$$

In which RCR is a recycling rate (in mass %) and  $\alpha_i$  the recycled product after  $i$  loops (which can be totally different to  $\alpha_0$ ). This equation is very flexible for comparing different waste valorisation scenarios. However, it has as a bottleneck that it does not consider the technical quality of the waste stream; i.e. not always all scenario's are possible for all waste streams. Therefore, the concept of this equation is modified towards a 'circular economy performance indicator' (CPI) which is defined as the ratio of the maximally obtainable environmental benefit over the actual obtained environmental benefit.

$$CPI = \frac{\text{actual benefit}}{\text{maximal benefit}}$$

The maximally obtainable benefit should then be determined based on the composition of the waste stream and the maximal avoided impact. In the case of plastics, a first proposal for such a classification is made based on % contamination and the interfacial tension ( $\gamma$  in mN/m) of the polymers present in the mixture.

These indicators are applied on three case studies in Flanders; one on domestic source separated plastic waste, one on plastic waste separated from WEEE and one on industrial waste from packaging production. For all three cases primary data is collected at the industrial production plants and the starting functional unit is 1 kg of plastic waste.

### 3. Results and discussion

In a first case study, the incineration of plastic waste is compared with closed loop recycling. For the recycling scenarios of source separated plastic waste and the plastic fraction in WEEE, the recyclability benefit rate respectively result in benefits of 73 and 78% whereas it result in 47 and 40% for incineration. This gives a very clear message to policy makers that closed loop recycling of these plastic waste fractions is on average 1.75 times better compared to incineration, whereas both scenarios are better compared to landfill. Furthermore, because of the fact that a ratio is made and there is a strong correlation between many impact assessment methods [7], the result is robust and relatively independent of choice of LCIA method. It also avoids the possible confusion in the different options of LCIA units. Because of this simplicity in result, this factor is being used to distinguish subsidies/taxes between the different waste scenarios [8].

In a second case study, the modified indicator is used to take into account the possibility of multiple open/closed loops. In this case there is the possibility to recycle the source separated domestic waste into plant trays or street benches where they replace PET, PS - concrete, wood or steel. The indicator highlights that attention should also be paid to the EOL of a recycled product as well, and in this case ideally, the recycled compounds should be used as long as possible to replace wooden street benches, which is information that can easily be used by both recycling companies and policy designers.

Avoided product	Benefit rate (%)	Avoided product loop 2	Benefit rate (%)
Plant tray PET	15	Plant tray PET	26
Plant tray PS- concrete	18	Street bench cast iron	32
Street bench cast iron	17	Plant tray PS -concrete	31
Street bench hardwood	22	Street bench - hardwood	39

*Table 1: Open-loop recyclability benefit rates for one-and two-step cascaded uses*

In a third case study, the CPI is calculated of different recycling scenario, starting from the technical quality of the waste stream. For a relatively pure post-industrial waste closed loop recycling is an optimal scenario (94%), whereas for a more polluted stream this is not technically feasible. In this case the CPI can only be calculated for open loop recycling and incineration and the results are CPI values of 16% and 36% respectively. This approach is shown to be very useful for policy makers to develop a policy for specific types of waste streams rather than one policy for all plastics.

### 4. Conclusions

Plastic waste is a complex stream and much LCA work has already been done to guide waste management strategies. However, the inherent complexity of LCA is often a drawback for policy makers to really implement these results. The use of clear indicators in that sense is of much added value. Obviously, from a methodological perspective there are many discussion points and improvements still possible, but on the other hand, the last four years of using the RBR related indicators in a policy context have shown that this type of indicators is very much appreciated.

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*Acknowledgement* - The authors thank the Flemish Government for their gentle support for the Flemish Policy Research Center for Sustainable Materials Management. The authors would also like to thank all industrial partners for their collaboration.